Research Problem Review 79-6

LEVEL II

HUMAN FACTORS EVALUATION OF A TACTICAL JAMMING SYSTEM (AN/MLQ-34, TACJAM) UNDERGOING OPERATIONAL TESTING

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FOREWORD

As the equipment used by the armed forces becomes progressively more complex it places a greater and greater demand on the individual soldier. In order to avoid overloading the mental and physical capabilities of this individual it is important to analyze newly developed weapons systems to determine how the man-machine interfaces of such weapons can best be designed for optimal utilization by the human operator. To this end the present human factors evaluation of a tactical jamming system was conducted in April 1978, at Fort Hood, Texas in response to a Human Resources Need sponsored by the TRADOC Combined Arms Test Activity (TCATA). The present report supplements the TCATA Operational Test 518 Report and contributed to determining system modifications and whether or not to enter low rate initial production of the system.

JOSEPH ZEIDNER
Technical Director

HUMAN FACTORS EVALUATION OF A TACTICAL JAMMING SYSTEM (AN/MLQ-34, TACJAM) UNDERGOING OPERATIONAL TESTING

BRIEF

Requirement:

This research was conducted as a human factors evaluation of a tactical jamming system (AN/MLQ-34, TACJAM), in response to a request from the TRADOC Combined Arms Test Activity (TCATA). The evaluation was conducted in conjunction with TCATA OT 518 (Tactical Communications Jamming System Operational Test II). This report is designed to supplement the TCATA OT 518 Test Report. It identifies man-machine interface problems which pose possible hazards to system operators and/or which reduce system effectiveness. It also suggests changes in hardware design, operating procedures, and training procedures which should alleviate these problems.

Procedure:

The methods used in collecting the data included questionnaires, interviews, and measurements of hardware. Data were collected on individual hardware components, workspace and equipment layout, environment, safety, operating procedures, training, and organizational maintenance. Analysis of the data focused on (1) determining what problems, if any, the TACJAM operators encountered in operating the system, and (2) how problems that were encountered might be corrected.

Principal Conclusions:

- Individual Components - Although the components of the system were generally found to be satisfactory from a human engineering perspective, it was determined that several equipment modifications would increase system efficiency. Examples include rearranging the switches on the function button panel so that a given switch is easier to locate, providing an external speaker inside the shelter for the VHF-FM communications system so that the operator does not have to monitor his handset, and locating the warning lights for the heat exchanger and air conditioners closer to the operator's primary field of view.

- Safety - Because of the high noise level that exists when the engine is driving the generator, system operators should be warned to wear ear protection when working near the cargo carrier.

- Operating Procedures - The Operator's Manual needs to be revised to correct numerous errors, expanded to include a better explanation of some functions, and reorganized so that it is easier for an operator to follow in a step-by-step manner.

- Training - Because most operators will likely be relatively intelligent soldiers who will be motivated to understand the whole system, the training program that will be developed for TACJAM operators should include at least a basic explanation of all of the panels in the system, even though an operator may not need to use all of them. Additionally, it is recommended that operators be trained to replace fuses.

- Organizational Maintenance - The extra tools (special allen wrenches and offset screwdrivers) that were issued to the test maintenance personnel by the system contractor should be issued to TACJAM maintenance personnel in order to enhance their ability to perform TACJAM maintenance. Also, the maintenance manuals should be revised to correct inaccuracies and to insure more complete coverage of maintenance tasks.

Utilization of Findings:

The findings of this research will be considered in conjunction with other test data to identify needed changes in equipment design, training programs, and operating procedures in order to maximize the effectiveness of the TACJAM system. The results will also be used as input to determine whether to enter low rate initial production of the system, and to assist in the design of future electronics warfare systems.

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INTRODUCTION

Any military system should be designed to be maximally effective because of the large costs that can be incurred in terms of lives and money in an armed conflict. This is particularly true of a jamming system on today's battlefield where a sophisticated aggressor can rapidly locate and bring artillery to bear on targets emitting high power electromagnetic signatures.

The AN/MLQ-34, TACJAM system is a high power, divisional level, tactical jamming system which is configured in a shelter mounted on an M548 full-tracked cargo carrier. Computer-tuned transmitters and receivers give the system the capability of jamming multiple targets simultaneously, and a pneumatically controlled antenna allows for rapid emplacement and displacement of the system.

In order to provide for maximum effectiveness of the TACJAM system the following human factors evaluation was carried out while TACJAM was undergoing an Operational Test II by TCATA at Fort Hood, Texas. The major purpose of the evaluation was to identify any man-machine interface problems that reduce the effectiveness of the system, and to alleviate such problems by recommending changes in hardware design, operating procedures, and/or training programs.

METHODOLOGY

Data of this research came from three sources: operators, maintenance personnel, and equipment. Data from the operators and maintenance personnel were obtained through interviews and questionnaires. Five operators were trained to operate the system, with four of them having the MOS of 98G (EW/SIGINT Voice Interceptor) and one having an MOS of 98C (EW/SIGINT Analyst). Two maintenance personnel were trained to maintain the system, with both of them having a 33S MOS.

Data from the hardware were obtained by taking measurements of the equipment.

QUESTIONNAIRES AND INTERVIEWS

The TACJAM system operators were asked to complete questionnaires concerning problems they encountered while operating the TACJAM system. The questionnaire (Appendix A) required the operator to rate the adequacy of various aspects of individual panels, workspace, environment, safety, operating procedures, and training. The questionnaire was administered to each operator individually as he sat in the operator's position inside the shelter. The interviewer sat next to the operator and manually recorded any verbal comments the operator wished to make as he gave a rating to each of the questions on the questionnaire. The operators were specifically asked to explain any Borderline, Inadequate, or Very Inadequate answers. Each questionnaire-interview session lasted from 1-1/2 to 2 hours. Because of the small number of operators available for interviews (N = 5) the results are not summarized in tabular form in the report for each question on the questionnaire. Instead, the number of operators making a given complaint or recommendation is presented in the text along with a summary of their comments.

During the interviews the operators indicated that they never operated several of the panels that were listed in the questionnaire. These included the antenna deploy junction box, the filtered 400 Hz power distributor circuit breaker panel, the digital data synchronizer, the multiplexer, the demultiplexer, and the exciter panels. Consequently, these panels were not rated by the operators.

One week after the questionnaire-interview sessions the operators were gathered together for an informal, unstructured group interview and were asked if they had any other comments to make about the system in general, and the operator's manual in particular. An operator's manual was provided for their review. This session lasted about 1/2 hour and all comments made by the operators were manually recorded by the interviewer.

The maintenance personnel were asked to complete two questionnaires (Appendices B and C) pertaining to their jobs as TACJAM maintenance men. Those comments which they made verbally to the questionnaire administrator, rather than on the questionnaire, were manually recorded. All of the results are summarized in the results section of this paper.

HARDWARE MEASUREMENTS

Measurements were taken of the TACJAM equipment itself in order to supplement the information from the questionnaire-interviews and to determine whether or not construction of the system was in accordance with the military standards listed in Military Standard 1472B and Military Handbook 759. The measurements included size, configuration, and style of knobs and dials, the location of frequently used panels,

and sound and light level measurements. The sound level measurements were taken on the db(A) scale using a 1565-B Sound Level Meter (General Radio) calibrated at 114 db(A). The light level measurements were taken with a Silicon cell Spotmeter (Kollmorgen Corp.).

Measurements that were not in accordance with military standards are so noted in the report.

RESULTS AND DISCUSSION

The TACJAM system is configured in such a way that there are three functional as well as structural parts to the system. Generally speaking, these parts can be characterized as: (1) System Set-up, (2) System Operation, and (3) System Checkout. Each of these will be discussed separately.

SYSTEM SET-UP EQUIPMENT

Those parts of TACJAM concerned with system set-up consist of the ground-rod driver assembly, the generator control panel, the emergency air supply switch, and the deploy switch and control for the data link antenna. Generally speaking, the operators found these parts to be adequate, although several suggestions were made for improving them.

Ground-rod Driver Assembly. The ground-rod driver assembly is located on the front of the vehicle and is used to drive a rod into the ground for the purpose of grounding the system. To operate the assembly the operator mounts a ground rod under the driver and depresses the power ON switch. The operators generally rated this piece of equipment as adequate, although two suggestions were made for improving the apparatus. First, one operator pointed out that in the course of setting up the TACJAM system one operator begins powering up the system and erecting the antenna while the other operator emplaces the ground rod. If the ground rod encounters a rock or other hard object hidden in the ground before it is completely emplaced, however, then the vehicle must be moved to another location to avoid the object. This necessitates lowering the antenna and powering down the system before moving the vehicle and can cause loss of valuable time in an intense combat situation. If the ground-rod driver assembly were mounted in such a way that it could be moved horizontally across the front of the vehicle, however, then the vehicle would not have to be moved whenever a rock or other immovable object interferred with emplacement. This idea should be given consideration in the design of future TACJAM systems.

Another comment made by one of the operators was that it might be useful to alter the ground rod driver assembly by attaching a winch

to it so that it can be used to remove rods from the ground when displacing the TACJAM system to another location. It is almost impossible to remove ground rods by hand, and in an intense combat environment where supply lines are likely to become burdened with other priorities, ground rods might be difficult to obtain. Thus, it would be very useful to have the capability of removing ground rods for repeated use.

Generator Control Panel. The generator control panel is located just behind the cab on the driver's side of the vehicle. It consists primarily of on-off switches for the generator and AC power, dials for checking power output, voltage, and frequency, and switches for controlling the antenna and the antenna mast door. The only comment made about this panel was by one operator who said that it is somewhat difficult to read the indicators and labels on the panel because of its high location (this operator was of average height; 5' 10" tall). Thus, consideration should be given to installing a foothold and handhold on the side of the vehicle so that the generator control panel is more accessible to TACJAM personnel.

Emergency Air Supply Switch. The emergency air supply switch is located just to the left of the d iver's seat in the cargo carrier, and is used to erect the antenna when the primary air supply system fails. No adverse comments were made about this switch.

Deploy Switch and Control for Data Link Antenna. This switch, located just inside the shelter door, is used to deploy the antenna that serves as a data link with other intelligence systems that are designed to control TACJAM from remote locations. The only unfavorable comment made here was that it is somewhat difficult to reach the switch and control when the shelter door is closed because the door handle is in the way. Locating the switch and control about six inches higher would alleviate this problem.

SYSTEM OPERATION EQUIPMENT

Those parts of TACJAM which are designed for the operator's use in intercepting and jamming enemy radio transmissions are configured in a single operator's console (Figure 1). Basically, this console consists of a TACJAM control panel, a function button panel, a receiver control panel, a keyboard, a plasma display indicator panel, and a panoramic indicator.

TACJAM Control Panel. This panel serves as the interface between the operator and the built in test equipment, the receivers and transmitters, and the communications and audio recording equipment. The operators rated this panel as adequate.

Function Button Panel. The function button panel (Figures 1 and 2) is used by the operator primarily to call up various pages from computer memory. There were several adverse comments made about this panel, along with recommendations for improving it.

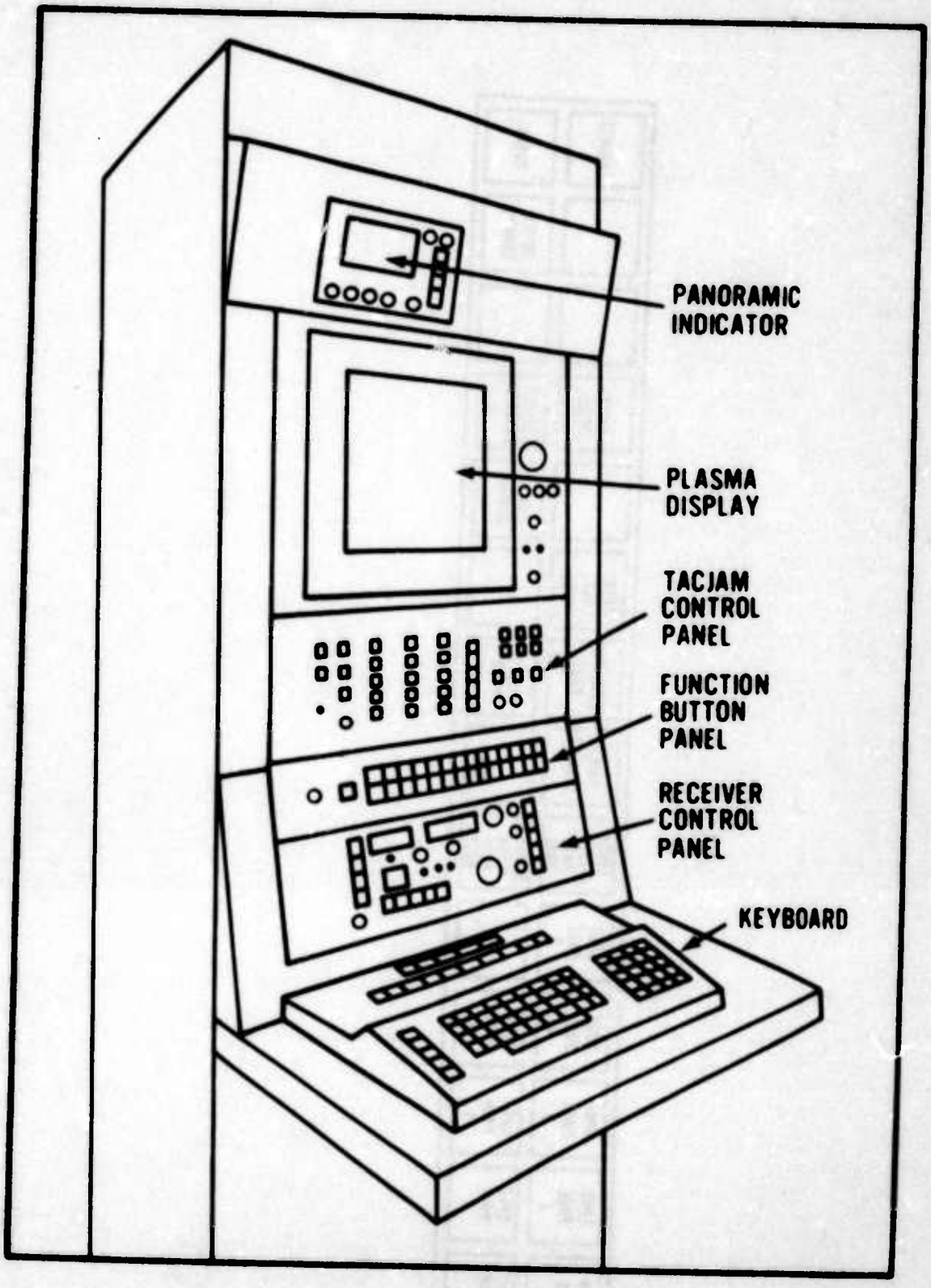

Figure 1. TACJAM Operator's Console

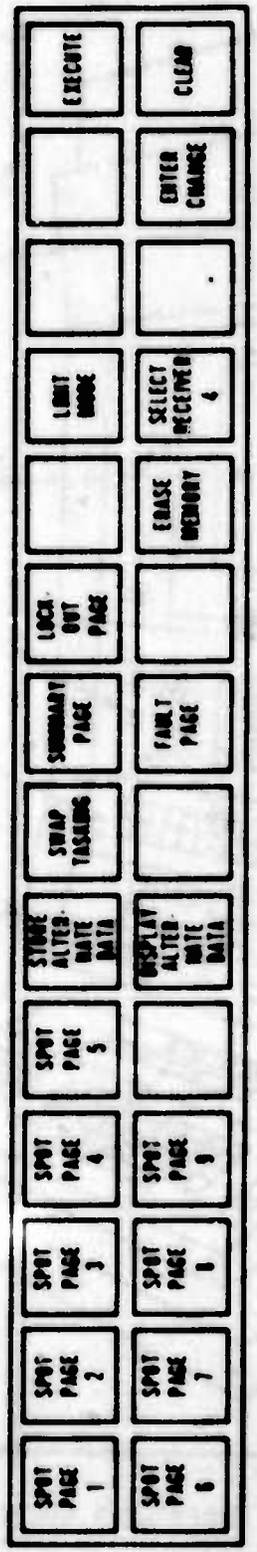

Figure 2. Function Button Panel

The first comment was made by the operator who had the most experience with the TACJAM system and was the only one who had operated it while wearing hand gloves. He rated the panel as borderline with respect to the spacing between the legend switches when wearing gloves because it is rather easy to accidently hit two switches at once when wearing gloves. This is not surprising because the function button panel is built with essentially no distance separating the two rows of switches and the adjacent switches in a given row. Designing this panel with an interswitch distance of at least 1/8 inch would mitigate this problem.

Another complaint about the function button panel was made by three of the operators and had to do with the organization or sequence of switches on the panel. It was suggested that the spot page switches be linearly arranged in a single row and that maximum use be made of the nonfunctional switches as spacers to help reduce the chances of hitting the wrong switch when an operator is in a hurry. Figure 3 shows a recommended arrangement of switches which takes these latter two comments into account and clusters switches together on the basis of function. It can be seen that the "spot page" switches are all arranged in the same row to facilitate locating a given switch, and the "execute" switch is located next to the "summary page" switch since it is used to execute commands entered in the summary page. Similarly, the switches concerned with alternate data ("store alternate spot," "display alternate spot," and "swap tasking") are collocated, and the "enter change" switch is collocated with the "fault page" and "lockout page" switches as well as located below the "spot pages" to facilitate entering changes into these pages.

Two other criticisms were made of the function button panel by one of the operators. First it was noted that the lamps behind the switches frequently burn out, thus making it somewhat difficult to read the legend on the switch. This problem could be alleviated by assigning the operator a supply of lamps and instructing them on how to replace the lamps when they burn out.

The other criticism that this operator made was that the amount of resistance exhibited by the switches varies so that sometimes a light touch activates a switch while at other times it seems that much more force is required. The problem with such differential switch sensitivity is that it breaks up an operator's work rhythm when he is operating the system and hence reduces his efficiency because he sometimes has to stop and retouch a switch that he though he already activated. This problem could be reduced by giving all of the switches the same resistance. (It should be noted in this regard that the minimum resistance that Military Standard 1472B recommends is 10 ounces, while the maximum is 40 ounces.)

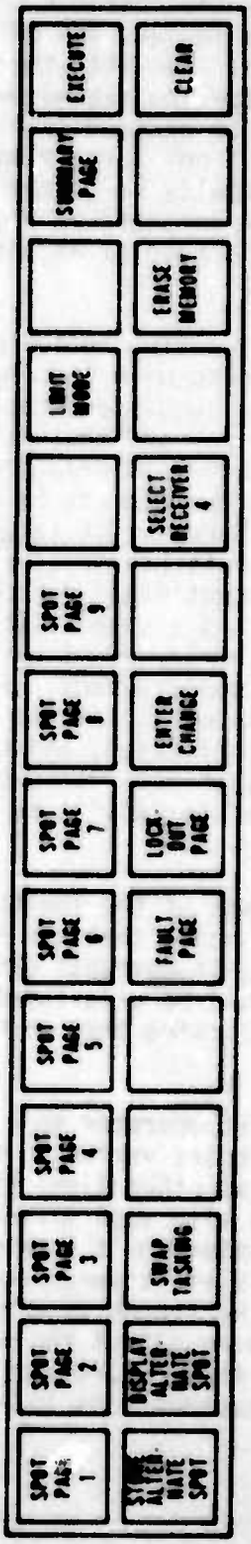

Figure 3. Recommended Switch Arrangement of Function Button Panel

Receiver Control Panel. The receiver control panel allows the TACJAM operator to tune the receivers to selected frequencies as well as adjust the receivers with respect to other characteristics such as mode, gain control, and bandwidth.

Two of the operators rated this panel as borderline with respect to the presence of unrelated and nonfunctional switches. They failed to see why controls such as the AF gain control, the AFC switch, and the STG STR/TUNE meter are on the panel if they have no function for TACJAM. Even though the operators realized that panels of a given design are often used in several different electronic systems with just the components appropriate to that particular system operational at the time, it seemed to serve as a mild irritant to them to have nonfunctional controls and displays on the panel. This problem, which can probably be solved by a proper training program, will be discussed later in this report.

The other problem, noted by one operator, was that the FAST PULSE AGC (Automatic Gain Control) switch and the MGC (Manual Gain Control) switch have a tendency to stick when they are pressed. Since this complaint was not made about any other switch or button on any other panel, the problem is probably unique to the particular switches on this receiver control panel and could be taken care of by organizational maintenance.

Keyboard. TACJAM operators use the keyboard to enter information onto the particular page from computer memory that is being displayed on the plasma display. The keys are like those found on a standard electric typewriter with extra keys added on the periphery for controlling certain system functions. Also, since this keyboard is used in other electronic systems there are some keys which are nonfunctional with respect to the TACJAM system.

Several criticisms were directed at this keyboard. First, the only operator to have operated the system while wearing gloves complained that the keys are too sensitive to the touch when one wears gloves, with the result that incorrect information is frequently entered onto the plasma display and has to be corrected, thus slowing the operator down and reducing his efficiency. (It should be noted that although the heat from the system will usually keep the temperature inside the shelter at a high enough level that gloves are not needed, gloves might very well be needed in a chemical environment.)

Another criticism of the keyboard, made by two of the operators is in contrast to the above criticism; namely, that sometimes a digit or letter will not register on the plasma display even though the operator is certain that he has pressed it. This problem is relatively common

and was demonstrated to the interviewer by one of the operators who typed an azimuth into the keyboard but only received the azimuth minus one digit as readout on the plasma display. The effect of such a problem is to slow down the operator when he is entering his tasking and in an intense combat situation this could have serious consequences. This problem is one that should be looked at in more detail by the engineers who are responsible for construction of the system.

The final criticism of the keyboard was made by four of the five operators and has to do with the extra nonfunctional keys located on the keyboard. That portion of the keyboard used by the operator includes: (a) the standard "QWERTY" keyboard section which is similar to the keyboard one would find on a standard electric typewriter, along with a few keys representing other symbols and controls, (b) a set of numeric keys and curser control keys, and (c) three indicator/control keys, one of which indicates that the keyboard is on, another which indicates that the CPU is busy, and a third which is used to set the keyboard in the only mode (alphanumeric) in which it functions. All other keys (25 total) have no function for the TACJAM system. As mentioned earlier, in this report, the operators reported some irritation over the presence of nonfunctional keys and switches and this was particularly true with the keyboard. Upon further questioning in the interview session it became apparent that what actually bothered the operators was being told not to worry about excess controls and indicators that have nothing to do with TACJAM. The operators were curious about the switches and keys and wanted some explanation as to what function they serve in other electronic systems. In short, the operators wanted a more complete understanding of the equipment, to even include the nonfunctional aspects of it. This matter will be further discussed in the training section of this report.

Plasma Display. The plasma display is used to display information which is contained in the various pages (spot, summary, fault, etc.) of computer memory to which the operator has access and can change. In addition, adjacent to the plasma display itself are a number of indicators and controls for the transmitters, the antenna mast, and communications.

The only comment about the plasma display itself was by one operator who said that he sometimes had difficulty locating the curser in the plasma display. However, none of the other operators had this problem. A more serious criticism, by two of the operators, concerned the commo call light which lights up when the central processing center is attempting to pass a secure message to TACJAM. The problem here, according to the operators, is that there is no such signal to indicate

to the operator when someone is attempting to pass a nonsecure message to TACJAM over the radio net that the TACJAM operator normally monitors over the handset. If the operator happens to be doing something that precludes him from monitoring the net, then he will miss the call and there is no way to communicate with him until he happens to get back to monitoring his assigned net. Building a visual signal into the system to indicate the presence of an incoming signal over the VHF-FM communications net would solve this problem.

Panoramic Display. The panoramic display is basically a cathode ray tube which graphically displays a signal that is being monitored by one of the TACJAM receivers. Its primary usefulness to the operator lies in the fact that it also displays signals occurring in a band of frequencies on either side of the primary frequency. The width of this band can be specified by the operators from .05 MHz minimum to 10 MHz maximum. The operators generally felt that this is an extremely useful piece of equipment. The only adverse comment, indicated by three of the operators, was that it is somewhat difficult to see the bottom part of the display when the operator is sitting close to the operator's console and operating the TACJAM controls. A small lip protrudes out from around the display screen and causes the operator to have to lean back away from the console to see the bottom line of the frequency display. Although adjustment of the botton line so that it is halfway up the screen itself is possible, this cuts off the top part of the signal that is being displayed at the time and thus reduces the information content which the operator receives. Eliminating the bottom part of the lip around the display would alleviate this problem.

SYSTEM CHECKOUT EQUIPMENT

The remaining TACJAM equipment which is located in the shelter is primarily concerned with providing the operator with information as to whether or not the system is functioning adequately (although there are some controls on this equipment which can also be classified under the heading of system operation).

Auxiliary Equipment Control Panels. The auxiliary equipment control panels are located on the wall adjacent to the operator's console. They consist of: (a) the remote control for the heat exchanger with indicator lights for low flow, low level, and high temperature, (b) the remote control for the air conditioners with indicator lights for dirty filters, (c) the remote control for changing channels on the GRC-103 radio, and (d) a thermometer.

Three operators criticised the location of these units because they are out of the operator's field of view when he is involved with operating

the equipment on the operators console. Consequently, the operator does not see the warning lights if they come on, as in fact happened in one case during the operational test. This is especially true of the heat exchanger lights. Lowering these units to a place on the shelter wall that is more parallel with the operators eye level (about 45 inches from the floor) would mitigate this problem, and using flashing red lights to indicate a faulty condition should eliminate the problem entirely.

Transmitter panels. The three transmitter panels are located directly behind the operator as he sits facing the operator's console. These panels primarily consist of indicator lights to signal the failure of basic power modules for each transmitter. No adverse comments were made about these panels. In fact, one operator pointed out that the location of the panels is quite convenient because their reflection can be seen in the plasma panel and consequently the operator can scan the indicator lights without having to turn around. The reflection, it should be noted, does not interfere with seeing any information that is displayed on the plasma panel.

Antenna control unit panel. The antenna control unit is the top unit in a rack of units located to the left of the operator as he faces the operator's console. The controls and displays on this unit panel allow the operator to sit and check the azimuth and polarization of the antenna during a jamming mission.

Two of the operators noted that one cannot read the indicators on the antenna control unit panel when one is sitting down because of its high location in the rack. Placing the unit in a lower location would help, even if it only involved switching places with the unit just below it (signal interface distribution unit).

The only other comment about this unit came out in the group interview session, where the operators recommended omitting the triple setting on the antenna select switch since there is only one antenna for the system. The two extra settings only serve to confuse the operator.

Signal interface distribution unit panel. This panel is located directly below the antenna control unit and consists mainly of indicator lights to signal a failed power supply, fuses, and several connectors for the operator's communications system. Three of the operators complained that it was a nuisance to have to unscrew the RF (radio frequency) cable of the site microphone from one connector and screw it into another when one wants to use the TACJAM antenna to communicate over his radio net rather than jam. They felt that it would be much more efficient to have a toggle switch in this position. However, it should

be noted that these particular connectors might have been designed as such for security reasons and, if so, should remain unchanged.

Audio recorder. The audio recorder is located just below the signal interface distribution unit and contains standard controls for recording verbal information on tape. The operators said that they never really used the controls on this unit (except to change tapes) because it can be controlled from the TACJAM operator's console. No adverse comments were made about it.

Receiver input unit. The panel on this unit, located just below the audio recorder, contains indicators to signal failed power supplies, two unit address thumbwheel switches, and a power on/off switch. The operators made no adverse comments about this panel.

Receivers. Four receivers are stacked vertically below the receiver input unit. There is a single indicator on the front of each receiver to indicate whether or not power is on. This indicator is red on all four receivers. Although the operators made no comments about the receivers, it should be noted that according to Military Standard 1472B, red is to be used to indicate a "no-go" or "failure" condition. A "go-ahead" or "ready" condition is to be denoted by the color green. Consequently, in order to be consistent, consideration should be given to changing the color of the receiver "power on" indicators from red to green. This comment also applies to the receiver input unit and the signal interface distribution unit, where the "power on" lights are yellow rather than green.

Computer control unit. The computer control unit panel located adjacent to the rack of boxes to the left of the operator, contains switches and displays which enable the operator to interface with the TACJAM computer. The most serious criticism of this panel was made by two of the operators and concerned that fact that the toggle switches on the panel are easily bent when someone brushes up against them when entering or leaving the shelter. Although none were broken off during the operational test, it would appear that this is a distinct possibility and action should be taken to prevent it. Attaching a hinged plexiglass shield to the panel would preclude such an accident and would appear to be the simplest solution to the problem.

Other comments about the computer control panel included the indication by the most experienced of the operators that it is somewhat cumbersome to operate the toggle switches while wearing gloves. Also, there was a comment by one of the other operators that he had not been instructed as to the meaning of the indicator lights above the address display and that as an operator he would like to know what function they served.

Amplifier control unit panel. This unit is the top unit in a rack which also contains a series of exciter panels. Generally speaking, it is situated in a location between the transmitter racks and the rack which contains the antenna control unit. It consists mainly of indicator lights, an RF meter, and a few power controls. The operators had no comments about this unit. It should be noted, however, that the "power on" light was yellow. As mentioned earlier, the color green is recommended for such signals in Military Standard 1472B.

Exciter panels. The exciter panels, located just below the amplifier control unit panel, consists of a series of indicator lights and an RF meter. The operators made no adverse comments about these panels. However, as mentioned above, the "power on" light is yellow, rather than green as Military Standard 1472B recommends.

Circuit breaker panel. The main circuit breaker panel is located adjacent to the amplifier control unit and the exciters. In addition to the circuit breakers, it has meters to display voltage and frequency. The operators rated this panel as adequate.

WORKSPACE AND EQUIPMENT LAYOUT

The operators rated the workspace of the TACJAM system as quite adequate, although one operator did complain of a lack of elbow room when using the writing table. A more serious concern, however, voiced by four of the operators concerned a lack of room for storing their combat gear. For a normal three man crew this would include three duffle bags, rations, five gallons of water, weapons, and ammo. When the crew moves the system from one location to another all of this gear, including the step ladder to the shelter, must be stored in the shelter with the TACJAM equipment and when a new location is reached it must all be unloaded. This would result in reduced efficiency in a combat situation that required TACJAM to frequently change locations because of the extra time and effort involved in loading and unloading the combat gear. However, the operators did state that there is enough room to operate the system even when the combat gear is stored in the shelter, although it is rather crowded.

None of the operator's were able to recommend another location in which the combat gear could be stored, although one operator did suggest adding a 1/4 ton truck to the TOE for transporting the combat gear. However, given the Army's attempt to keep the number of transport vehicles down to a minimum, and given the added logistical burden this would place on a unit, this suggestion is probably not very realistic. A potential solution is to weld a rack onto the back of the cargo door below the air conditioning units. Such a rack could be built large enough to hold the duffle bags and water can which make up the bulk of the combat gear, and would not be in the way of any part of the TACJAM system.

With respect to the layout of panels, in terms of how well they can be seen and how accessible they are, the operators had no adverse comments with the exception of the location of the antenna control unit panel and the heat exchanger warning lights. Both of these were mentioned earlier.

Determination of the angles between the various panels of the operator's console and the operator's line of sight indicated that the console met the military standards listed in Military Handbook 759. The handbook recommends that the top of the uppermost console panel be no more than 45^{o} above the operator's horizontal line of sight, and the bottom of the lowermost console panel, excluding the keyboard, be no more than 50^{o} below the horizontal line of sight. These angles for the TACJAM system were 47^{o} and 45^{o}, respectively, thus corresponding quite well to the military recommendations. The operators console also met military standards with respect to lateral field of view. All of the panels of the console were within 24^{o}, laterally, of the operators forward line of sight, which is well within the maximum of 35^{o} listed in Military Standard 1472B.

Other dimensions of the operator's console, such as overall height, seating height, and amount of leg room, were very close to military standards, exceeding them by no more than several inches in each case. In general, the layout of the system was well planned with respect to military standards.

ENVIRONMENT

The operators rated the operating environment inside the shelter as adequate with respect to temperature, ventilation, noise, vibration, and illumination, although one operator stated that the noise and vibration from the generator did become somewhat annoying after three or four hours of continuous operation inside the shelter.

Sound level measurements inside the shelter with the TACJAM system in operation varied from 77 to 82 db(A), depending upon whether or not all three transmitters were transmitting at the time. These levels are within tolerable sound level limits. Standards for excessive sound levels are only concerned with levels at 90 db and above (e.g. Ward, 1966; McCormick, 1976).

The sound level outside of the shelter, however, was higher and of more concern. While the engine was driving the generator the sound level reached 98.5 db(A) on the exhaust side of the cargo carrier and 94 db (A) on the nonexhaust side (with measurements taken 1 foot away from the cargo carrier). In the driver's position in the cab of the cargo

carrier the sound level reached 102 db (A). These levels are quite high and are above the levels at which one begins to risk permanent hearing threshold shifts after prolonged exposure to such noises. In this regard it should also be noted that four of the operators rated the extreme loudness of the cargo carrier as a safety hazard. Consequently, the operators should be provided with and warned to wear some sort of ear protection when they are working near the cargo carrier while the TACJAM system is operating, in addition to being warned to wear ear protection when operating the M548 Cargo Carrier itself.

With respect to illumination levels, it should be noted that the illuminance of the operator's console panels and other panels inside the shelter were no more than 15 foot candles as measured with a spotmeter. Although this is much lower than the minimum standard of 30 foot candles listed in MIL-STD 1472B, the operators did not feel that the illumination was insufficient. A TACJAM operator actually does not spend much time operating controls on the various TACJAM panels. After entering the initial tasking data, which can usually be done in five or ten minutes, he primarily concerns himself with the system displays (plasma display, panoramic indicator) which have good contrast characteristics and are easily observed. Consequently, the low illumination level in the TACJAM shelter can be considered satisfactory for the tasks which TACJAM operators normally perform.

SAFETY

Besides the extreme loudness of the cargo carrier mentioned above, there was one other safety problem which was mentioned by the operators. It was noted that one operator received a burn on the arm when he accidently rubbed against the vehicle exhaust pipe while removing the power cable from the on-board generator. It would thus seem reasonable to include a warning in the operator's manual and the maintenance manual that the exhaust pipe becomes quite hot and that one should keep this in mind when working with the power cables in that area.

OPERATING PROCEDURES

The operators were asked to evaluate the adequacy of the procedures they were taught for operating the TACJAM system, as well as the adequacy of the Operator's Manual in explaining those procedures.

Procedures. The major concern of the operators with respect to operating procedures had to do with maintenance of the system. The operators reported that they were not authorized to do even the simplest types of maintenance tasks, like replacing fuses. This seemed to cause

the system to be down for periods of time that were really unnecessary while waiting for an organizational level maintenance man to arrive and replace the fuse. A pertinent example involves the antenna control unit. On a windy day it is common for a fuse to blow in this unit. Replacing it should not take very long, but it does simply because of the time expended while waiting for organizational maintenance to replace it.

Training and authorizing TACJAM operators to identify and replace fuses would increase the efficiency of the system by markedly reducing the down time due to blown fuses. Along this line, it should be noted that several operators felt that they should also be trained to replace boxes in the TACJAM system since in some cases the system will indicate that a given box has a fault in it. Replacing the box primarily involves unscrewing the appropriate screws to remove the box from its rack, transferring cables from the old box to the new box, setting the address on the new box, and screwing the new box in place. Training operators to perform this task would appear to require a relatively small amount of time and would increase efficiency of the system both in terms of reducing system down time and in reducing the number of maintenance man hours needed to maintain the system.

There were several other comments made about operating procedures. One of these comments concerned the problem of obtaining the codes for types of modulations acceptable to the jammer. When the operator wishes to enter the type of modulation he wants the jammer to employ he either has to rely on his memory for the type of modulations that are acceptable and the appropriate code for it that is recognizable by the system, or he has to have the codes written down and posted on the wall of the shelter as the operators in this test did. Two of the operators suggested that the modulation codes be entered into the computer software so that an operator can access them through a "modulation code page" like he accesses a summary page or spot page. This appears to be a reasonable way of improving the system.

Another major comment concerned the communications system. The operators complained that there is no way to know that someone is attempting to contact them over the VHF-FM radio unless the operator is specifically monitoring that radio over the handset (the external speaker for the radio is mounted in the cab of the cargo carrier rather than inside of the shelter). Usually, however, the operator will be monitoring enemy communications over one of the TACJAM receivers, or will be concerned with some other aspect of the TACJAM system and will not be able to monitor the VHF-FM radio. This necessitates having another operator sit in the cab of

the cargo carrier and monitor this radio. Having an external speaker located inside the shelter so that the operator can monitor VHF-FM communications while performing his TACJAM functions would solve this problem.

A final comment made by the operators pertained to the process of moving the shelter on the carrier and tieing it down. The shelter must be moved toward the rear of the cargo carrier in order to perform preventive maintenance on the generator. This involves releasing the guy wires that hold the shelter in place on the cargo carrier and jacking the shelter on its skids toward the rear of the carrier. The operators complained that there is really no place to stand and get firm footing when releasing or securing the guy wires that tie the shelter down. Furthermore, they said that is difficult to sufficiently tighten the nuts on the vertical guy wires. The operators felt that one reason for this is that they are not supplied with a large enough wrench for torquing the nuts as much as is needed to tighten them securely. However, one operator said that even when a large wrench was obtained and used the nuts still worked loose and the guy wires loosened up. The operators reported that this problem did not appear to happen with the diagonal guy wires. Consequently, it would appear that this is a design problem that must receive further consideration by the engineers who designed the system.

Operator's Manual (TM32-5895-213-10). The operator's manual was severely critized by all of the operators, especially in the group interview session. Their general comments were that it is poorly organized, omits some important information, and contains numerous errors.

With respect to the organization of the manual, the operators indicated that they would prefer a manual which would proceed in the same order that one actually sets up, operates, and shuts down the system. Thus, rather than beginning with a description of all of the parts of the TACJAM system, followed by instructions on how to operate the system, the operators would prefer a sequence in which the first step in setting up the system is explained, like setting the ground rod, at the same time that the parts of the ground rod are described. This would then be followed by a description of, say, the generator control panel and how the operator interacts with it in preparing the system for operation, and so on through system operation and system shut down.

Actually, several of the operators thought that two operator's manuals would be useful. One manual should be brief and simple, containing little detail and mainly concerned with presenting the operator

with just enough information for setting up, operating, and shutting down the system. This could essentially be an initial training manual and quick reference manual for normal operating procedures. The other manual should be a more detailed description of the system, containing all the information that a reasonably intelligent operator might want to know. This manual would be a somewhat expanded version of the current operator's manual and would include detailed information on preventive maintenance as well as some information on organizational maintenance (such as information on changing boxes and replacing fuses). Although this idea should be given consideration, the redundancy that would occur in having two manuals might make the gain not be worth the extra effort involved in producing two manuals. Reorganizing the current manual and expanding the maintenance section does, however, appear to be worthwhile.

With respect to inaccuracies, in the manual, the operators cited several examples which they said were characteristic of problems throughout the manual. These are listed in Table 1 and are not intended to be exhaustive but rather are indicative of the types of errors that should be looked for and corrected throughout the manual.

In some cases the operators felt that, rather than being in error, the manual was simply not detailed enough. For example, the modulations and corresponding deviations which are acceptable to the jammer are listed in Table 2-26 on page 2-91 but the operators felt that there was not sufficient discussion or explanation as to which modulations should be used under which circumstances. The only solid piece of advice in this respect was that FMNB, 7.5 KHz is a good all-purpose selection (pg 2-95). It was felt that this is not enough information with which to become a good, efficient TACJAM operator and that a more detailed discussion of the remaining modulation types is needed.

TRAINING

The TACJAM operators received little formal training on the TACJAM system. The most experienced operator learned to operate the system over a two month period at Ft. Huachuca where his training primarily consisted of playing with the system until he learned how to operate it. This operator was with the system during developmental testing at Ft. Huachuca and also served as one of the operators during the operational test at Fort Hood. This operator gave a "very confident" rating to his ability to carry out a TACJAM mission.

The remaining four operators received a week of training on the system at Fort Hood just before the operational test was begun. This

Table 1

EXAMPLES OF ERRORS IN OPERATOR'S MANUAL (TM32-5895-213-0)

Pg.	Description of Error
1-2	The designation "M458 Cargo Carrier" is incorrect. "M548 Cargo Carrier" is correct.
2-17	Paragraph 1-7, referenced under the intensity control section, does not exist.
2-18	The 20 MHz position is not mentioned here.
2-22	The ERASE ENBL key referenced in the ERASE SCRN section does not exist on the TACJAM keyboard.
2-64	Figure 2-26, referenced under section d, does not show the pneumatic pressure gauge.
2-69	The address indicators referenced in section b primarily display numbers in the 40,000's rather than the 30,000's. Also, when the location set in the data switches is 300, the data indicators display 002301 rather than 002401. (This also applies to page 2-72).
2-70	The summary page depicted here is from the initial TACJAM system that had three antennas. The summary page on the current TACJAM only shows information pertinent to one antenna.
2-78	Figure 2-26, referenced in section (1), does not show the heat exchanger toggle switch because the cargo door is closed in the figure.
2-85	The above comment about the summary page also pertains to the photo of the spot page.
2-98	In section b the unit of measurement which describes an acceptable relationship between the antenna and a spot azimuth is not listed. It should be 30 degrees.

training was a mixture of classroom lecture and hands on training, both of which were given and supervised by the operator mentioned above and by the individual who performed organizational and intermediate level maintenance on the system.

In response to the question of how confident they felt in their ability to carry out a TACJAM mission right after receiving this week of training, three of the operators gave ratings of "Borderline" and one operator gave a rating of "Confident". However, after seven weeks of operating the system in the operational test three of the operators said they were "Very Confident" of their ability to carry out a TACJAM mission and the other operator said he was "Confident" that he could do so also. Even though the operators did not feel fully confident in their ability to operate the TACJAM system after their one week training session, they had few specific complaints about the training. The only major complaint came out in the group interview and concerned the communications system. The operators felt that they did not have a good understanding of how the VHF-FM communications system worked in terms of, for example, the relationship between the VHF communications system in the cab of the cargo carrier and the VHF communications system in the TACJAM shelter. They emphasized that any training program that is developed for training TACJAM operators should definitely include the VHF-FM communications system on TACJAM.

With respect to recommendations for someone who is developing a training course for TACJAM operators, a number of suggestions were offered in addition to the comment about VHF-FM communications. First it was suggested that all of the boxes in the system be explained to the operator, not just the ones with which he is going to be dealing. For example, generally explaining the functions of the exciters, the signal interface distribution unit, the automatic mode switching unit, and other boxes with which the operator has little or no interaction would give the operators more confidence in their ability to utilize the system effectively. One should note that the soldiers who were selected to operate the TACJAM system were relatively intelligent individuals who were curious about the system as a whole, were motivated to understand it, and found it very frustrating when they could not find a satisfactory explanation of some part of the TACJAM system in the operator's manual or were told by more knowledgeable persons not to worry about it since it did not directly affect their job as operators. Most individuals who are relatively intelligent, like the TACJAM operators in this test and like the TACJAM operators of the future most likely will be, are curious about things with which they interact and keeping information from them or not making it readily available to them

serves only to decrease their motivation to do a good job and, in this case, prevents the Army from getting the best performance from a system with tremendous potential for disrupting enemy communications. The extra effort that would be involved in providing operators with a basic understanding of the whole system from an instructor who thoroughly understands the system would, in the long run, seem to pay dividends far in excess of the costs.

Related to this issue is the operator's comments that they would like to be trained and authorized to change boxes and fuses. It seems highly inefficient not to capitalize on the superior general technical abilities of individuals in military intelligence and train them to perform basic organizational maintenance tasks like replacing blown fuses and black boxes. This issue was mentioned earlier.

Another related issue concerns the nature of the training which operators receive. It was felt that after an initial period of formal instruction the operator should be given time to just operate the system by himself without anyone else around to interfere with his actions. This way he could experiment with the system and become more familiar with it by trying out functions and operations about which he was not confident, and feel free to practice those operations with which he felt he needed more experience.

Finally, the operators mentioned that a formal training program should include detailed instructions on how to perform preventive maintenance on the generator and engine of the M548 cargo carrier, (such as what types of lubricants go where), and should also include refresher training on map reading because the TACJAM system is expected to move about on the battlefield on its own.

ORGANIZATIONAL MAINTENANCE

Training received. Both of the maintenance men received organizational maintenance training on the TACJAM system by the contractor that developed the system. This training lasted about one week and was given about one month before the system arrived for operational testing at Ft. Hood. In the case of one maintenance man the training was received after spending around five months learning about the system on the job while the system was undergoing developmental testing at Ft. Huachuca and White Sands Missile Range. For the other maintenance man the training was received right after completing training for the 33S MOS at Ft. Devens. Thus, one maintenance man had extensive experience acquired by actually maintaining the TACJAM system during both developmental and operational testing, while the other maintenance man's experience was primarily

limited to the contractor's course and some experience with maintaining the system during the two months of operational testing at Ft. Hood.

Test equipment. The maintenance man with the lesser amount of experience said that he did not have the opportunity to use any of the TACJAM test equipment and thus could not evaluate it. The more experienced maintenance man rated the built-in test equipment as "Extremely useful", the test maintenance and diagnostic equipment was "Somewhat useful", and the automated test equipment as "Not at all useful". His major complaint against the automated test equipment was that as it is currently configured it can only diagnose problems down to bad cards in a box, which a good maintenance man can do by himself, anyway, without the automated test equipment. Thus, the equipment really isn't necessary.

Repair. Both maintenance men gave the TACJAM system "adequate" ratings with respect to accessibility of test points and ease of replacing subcomponents and major components.

Tools. The TK-105 tool kit was issued to the maintenance men for maintaining the TACJAM system. In addition, the contractor issued one of the maintenance men a special set of allen wrenches with straight enlarged handles (so one could get more leverage than he could with the standard bent handle allen wrench) and a special set of offset screw drivers. It was felt that these tools were needed to adequately trouble shoot the system.

Special Skills. Neither maintenance man felt that any special skills, other than those a 33S MOS would normally have, are necessary for performing organizational maintenance on the system. The lesser experienced maintenance man, however, felt that being given time to merely play with the system in order to become familiar with it at one's own pace would be helpful.

Maintenance procedures. Both of the maintenance personnel felt that most of the organizational level maintenance could be performed by the operators. Maintenance at this level mostly involves replacing blown fuses and exchanging boxes. In some cases the built-in test equipment tells one when there is a fault in a given box and in such cases it would be relatively simple for an operator to exchange a box and leave the maintenance men free to concern themselves with more complex problems. The two maintenance men actually felt that a 33S would be very underutilized in performing the current organizational level maintenance on TACJAM.

Repair parts. The only problems that were encountered in obtaining repair parts involved replacing the function button panel and the antenna control panel. An earlier version of TACJAM had to be cannibalized in order to obtain replacements for these panels. This is not indicting of the supply system, however, since only one copy of the revised system has been built to date. Thus, the adequacy of the supply system to support the TACJAM system cannot be adequately evaluated at this time because of the system's uniqueness and current low density.

Technical manuals. Both of the maintenance personnel were rather critical of the TACJAM maintenance manual (TM 32-5895-213-24). Their dissatisfaction centered on both accuracy and completeness. They reported that they had observed numerous errors in the manual, such as the pressure inside the emergency air supply bottle being listed as 4 pounds in the manual, but as 2 1/2 pounds on the bottle itself. In addition many things were not listed that should be listed, such as addresses for the boxes, J numbers, and cable labels in the block diagrams.

Finally, it was pointed out that it appeared as if the manual had been written for the original version of the TACJAM system and had been inadequately revised for the current version of the system.

CONCLUSIONS AND RECOMMENDATIONS

Generaly speaking, the TACJAM system is well designed from a human factors engineering point of view. However, there are a number of ways in which the system can be improved. These are listed in the following remarks and it is recommended that adoption of these suggestions be given serious consideration.

SYSTEM SET-UP EQUIPMENT

Ground-rod driver assembly.

1. Designing the ground-rod driver assembly so that it can be moved horizontally across the front of the vehicle to avoid objects that may be hidden beneath the point at which the ground rod needs to be emplaced would reduce system set up times in some situations and thus increase the efficiency of the system.

2. A winch that can be used to remove ground rods should be added to the system.

Generator Control Panel.

A foothold and handhold should be installed on the side of the cargo carrier below the generator control panel so that operators have more ready access to it.

Deploy Switch and Control for Data Link Antenna.

This switch should be located about six inches higher so that it is more accessible when the shelter door is closed.

SYSTEM OPERATION EQUIPMENT

Function Button Panel.

1. The interswitch distance should be increased, if possible, to prevent the operator from accidently hitting two switches at the same time.

2. The arrangement of the switches should be changed to an arrangement that is more functional.

3. A supply of lamps which light the switches should be provided to the operator so that he can replace burned out lamps when necessary.

4. The pressure resistance should be the same for all of the switches so that the TACJAM operator can maintain a steady rhythm of work and not have to return to a switch that he has already visited.

Receiver Control Panel.

Nonfunctional controls and meters should be removed if possible.

Keyboard.

1. The keyboard should be examined to determine whether operators reports of key malfunctioning are unique to the keyboard that was tested or indicate a problem with the design of the keyboard and associated electronics.

2. Nonfunctional keys should be either removed or covered.

Communications Call Light.

Provision should be made for a Communications Call Light to come on when a nonsecure signal is coming in over the VHF-FM communications net.

Panoramic Display.

The small metal lip which protrudes from the bottom of the CRT display should be removed, or the panoramic display should be tilted to a greater angle, so that the operator can see the whole display while he is operating the TACJAM operator's console.

SYSTEM CHECKOUT EQUIPMENT

Auxiliary Equipment Control Panels.

1. The remote controls for the heat exchanger and the air conditioners, should be located in a place lower down on the side of the shelter so that they are closer to the operator's primary field of view.

2. The red lights on these panels should be designed to flash at a rate of three to five times a second under appropriate conditions.

Antenna Control Unit Panel.

1. The unit should be located in a lower position in the rack if possible (such as where the signal interface distribution unit is located), so that the operator can read the indicators while remaining seated at the operator's console.

2. The three position setting for the antenna select switch should be changed to a one position setting or eliminated completely to avoid confusing the operator.

Signal Interface Distribution Unit Panel.

The "power on" indicator light should be green rather than yellow.

Receiver Input Unit.

The "power on" indicator light should be green rather than yellow.

Receivers.

The "power on" indicator light should be green rather than red.

Computer Control Unit Panel.

The toggle switches should be protected from accidental bending and breaking by individuals entering and leaving the shelter. Providing a plexiglass cover is a possible solution.

Amplifier Control Unit Panel.

The "power on" indicator light should be green rather than yellow.

Exciter Panels.

The "power on" indicator lights should be green rather than yellow.

WORKSPACE AND EQUIPMENT LAYOUT

Consideration should be given to designing a place for storing the TACJAM operators' combat gear other than in the shelter with the TACJAM console. One possibility is to attach a rack to the cargo carrier rear door.

ENVIRONMENT AND SAFETY

1. Because of high noise levels, the operators' manual should provide a warning to the operators to wear ear protection when working around the cargo carrier while it is driving the generator.

2. A warning should be listed in the Operator's Manual and posted near the exhaust pipe that care should be taken not to touch the exhaust pipe when the engine has been running because of the high temperature of the pipe.

OPERATING PROCEDURES

1. The Operator's Manual (TM 32-5895-213-10) needs to be revised to correct numerous errors, expanded to include a better explanation of some functions (such as modulations), and reorganized so that it is easier for an operator to follow in a step-by-step manner.

2. It would be helpful to include a listing of the modulation codes in the computer software so that they can be called up when an operator wished to review the types of modulations available for his use.

3. The system needs to be modified so that an operator who is working at the operator's console can be made aware of an incoming signal over the VHF-FM communications system. Either a communications call light or an external speaker would solve this problem.

4. The problem of the vertical guy wires which hold the shelter down working loose should be investigated further to determine whether the operators did not have a large enough wrench for torquing the nuts on the wires or whether a different way of securing the shelter needs to be developed.

TRAINING

1. The training program that will be developed for TACJAM operators should include an explanation of all of the panels and pieces of equipment that make up the TACJAM system. Most operators will likely be intelligent soldiers who will be motivated to understand the whole system and will possibly become frustrated and unmotivated if they are not given at least a general explanation of each part of the system. Such an explanation would also give the operators more confidence in their ability to effectively operate the system.

2. Operators should be taught to replace fuses. Requiring organizational maintenance personnel to perform this function is inefficient. Maintenance personnel would be more efficiently used if they were required to become involved only when the replacement fuse also blows shortly after it has been put in place.

3. Consideration should be given to training operators to replace boxes when the built-in test equipment indicates which box is bad. This was suggested by both operators and maintenance personnel.

4. A training program should include some time for an operator to work with the system by himself so that he can answer some of his questions about it by trying out different procedures on his own and can practice those operations on which he feels he needs more experience.

5. A training program should include detailed instructions concerning preventive maintenance on the generator and engine of the M548 Cargo Carrier.

ORGANIZATIONAL MAINTENANCE

1. The extra tools (special allen wrenches and offset screwdrivers) issued to the maintenance personnel by the system contractor should be issued to future TACJAM maintenance personnel.

2. The maintenance manuals (TM 32-5895-213-24) needs to be revised to correct inaccuracies and to insure more complete coverage of maintenance tasks. Including addresses for boxes and listing J numbers and cable labels would make the manual much more useful.

REFERENCES

McCormick, E.J. Human Factors in Engineering and Design. 4th Ed, 1976, pg. 373-374.

MIL-HDBK-759. Human Factors Engineering Design for Army Materiel. 1975.

MIL-STD-1472B Human Engineering Design Criteria for Military Systems, Equipment and Facilities. 1974.

Ward, W.D. "Proposed damage risk criteria for intermittent noise exposure." Proceedings XV International Congress on Occupational Health, Paper AIV-36, pg. 143-149, September, 1966.

APPENDIX A

TACJAM HUMAN FACTORS QUESTIONNAIRE-INTERVIEW FOR OPERATORS

April 1978

U. S. Army

Research Institute for the Behavioral and Social Sciences

TACJAM Human Factors Questionnaire-Interview For Operators

Name: _____ Date: _____

The purpose of the following questionnaire is to obtain your opinion about the adequacy of the TACJAM system from an operator's point of view. This will be accomplished by soliciting your answers to a number of questions and by giving you the opportunity to make any additional comments you wish. Take as much time as you feel is necessary to adequately answer the questions. The interviewer will answer any questions you may have and will write down any comments you would like to make about the equipment.

I. Individual Components

A. Using the scale to the right indicate with a check mark (√) how adequate the TACJAM Control Panel is in each of the following areas:

	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

2. **Please explain any Borderline, Inadequate, or Very Inadequate answers:**

B. Using the scale to the right indicate with a check mark (✓) how adequate the Function Button Panel is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

2. Please explain any Borderline, Inadequate, or Very Inadequate answers:

C. Using the scale to the right indicate with a check mark (√) how adequate the receiver control panel is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. BANDWIDTH and FREQUENCY DISPLAYS					
a. Display brightness	___	___	___	___	___
b. Absence of glare	___	___	___	___	___
c. Absence of flicker	___	___	___	___	___
d. Viewing distance	___	___	___	___	___
e. Angle of view	___	___	___	___	___
f. Correct labels	___	___	___	___	___
g. Other (specify)_____ _____.	___	___	___	___	___
2. CONTROLS					
a. Size (without gloves)	___	___	___	___	___
b. Size (with gloves)	___	___	___	___	___
c. Shape (without gloves)	___	___	___	___	___
d. Shape (with gloves)	___	___	___	___	___
e. Spacing between controls (without gloves)	___	___	___	___	___
f. Spacing between controls (with gloves)	___	___	___	___	___

	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—
m. Visibility of controls	—	—	—	—	—
n. Angle of view	—	—	—	—	—
o. Location of critical controls	—	—	—	—	—
p. Reach distance of critical controls	—	—	—	—	—
q. Location of noncritical controls	—	—	—	—	—
r. Reach distance of noncritical controls	—	—	—	—	—
s. Functional grouping (controls with related functions are grouped together)	—	—	—	—	—

t. Control type (type of control is appropriate for type of function) ___ ___ ___ ___ ___

u. Other (specify)_____
_____. ___ ___ ___ ___ ___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

D. Using the scale to the right indicate with a check mark (✓) how adequate the <u>keyboard</u> is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—

	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

2. Please explain any Borderline, Inadequate, or Very Inadequate answers:

E. Using the scale to the right indicate with a check mark (✓) how adequate the <u>plasma display Indicator Panel</u> is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. PLASMA DISPLAY					
a. Display brightness	___	___	___	___	___
b. Absence of glare	___	___	___	___	___
c. Absence of flicker	___	___	___	___	___
d. Letter discrimination	___	___	___	___	___
e. Viewing distance	___	___	___	___	___
f. Angle of view	___	___	___	___	___
g. Other (specify)_____ _____.	___	___	___	___	___
2. INDICATOR PANEL DISPLAY					
a. Display brightness	___	___	___	___	___
b. Absence of glare	___	___	___	___	___
c. Absence of flicker	___	___	___	___	___
d. Viewing distance	___	___	___	___	___
e. Angle of view	___	___	___	___	___
f. Correct labels	___	___	___	___	___
g. Other (specify)_____ _____.	___	___	___	___	___

	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
3. INDICATOR PANEL CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

4. Please explain any Borderline, Inadequate, or Very Inadequate answers:

F. Using the scale to the right indicate with a check mark (✓) how adequate the <u>panoramic indicator</u> is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. DISPLAY					
a. Display brightness	___	___	___	___	___
b. Absence of glare	___	___	___	___	___
c. Absence of flicker	___	___	___	___	___
d. Information content	___	___	___	___	___
e. Information precision	___	___	___	___	___
f. Method of presenting information	___	___	___	___	___
g. Viewing distance	___	___	___	___	___
h. Angle of view	___	___	___	___	___
i. Other (specity)_____ _____.	___	___	___	___	___
2. CONTROLS					
a. Size (without gloves)	___	___	___	___	___
b. Size (with gloves)	___	___	___	___	___
c. Shape (without gloves)	___	___	___	___	___
d. Shape (with gloves)	___	___	___	___	___
e. Spacing between controls (without gloves)	___	___	___	___	___

	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
f. Spacing between controls (with gloves)	—	—	—	—	—
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—
m. Visibility of controls	—	—	—	—	—
n. Angle of view	—	—	—	—	—
o. Location of critical controls	—	—	—	—	—
p. Reach distance of critical controls	—	—	—	—	—
q. Location of noncritical controls	—	—	—	—	—
r. Reach distance of noncritical controls	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

C. Using the scale to the right indicate with a check mark (✓) how adequate the Auxiliary Equipment Control Panels are in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

2. Please explain any Borderline, Inadequate, or Very Inadequate answers:

H. Using the scale to the right indicate with a check mark (✓) how adequate the Antenna Deploy Junction Box is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—

	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

2. **Please explain any Borderline, Inadequate, or Very Inadequate answers:**

I. Using the scale to the right indicate with a check mark (✓) how adequate the Filtered 400 Hz Power Distributor Circuit Breaker Panel is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

2. Please explain any Borderline, Inadequate, or Very Inadequate answers:

J. Using the scale to the right indicate with a check mark (✓) how adequate the TACJAM Transmitter Panel is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. DISPLAYS					
a. Display brightness	—	—	—	—	—
b. Absence of glare	—	—	—	—	—
c. Absence of flicker	—	—	—	—	—
d. Viewing distance	—	—	—	—	—
e. Angle of view	—	—	—	—	—
f. Correct labels	—	—	—	—	—
g. Other (specify)_____ _____.	—	—	—	—	—
2. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—
m. Visibility of controls	—	—	—	—	—
n. Angle of view	—	—	—	—	—
o. Location of critical controls	—	—	—	—	—
p. Reach distance of critical controls	—	—	—	—	—
q. Location of noncritical controls	—	—	—	—	—
r. Reach distance of noncritical controls	—	—	—	—	—
s. Functional grouping (controls with related functions are grouped together)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

K. Using the scale to the right indicate with a check mark (✓) how adequate the Power Interlock Panel is in the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. METERS					
a. Display brightness	___	___	___	___	___
b. Absence of glare	___	___	___	___	___
c. Absence of flicker	___	___	___	___	___
d. Viewing distance	___	___	___	___	___
e. Angle of view	___	___	___	___	___
f. Correct labels	___	___	___	___	___
g. Other (specify)_____ _____.	___	___	___	___	___
2. CONTROLS					
a. Size (without gloves)	___	___	___	___	___
b. Size (with gloves)	___	___	___	___	___
c. Shape (without gloves)	___	___	___	___	___
d. Shape (with gloves)	___	___	___	___	___
e. Spacing between controls (without gloves)	___	___	___	___	___
f. Spacing between controls (with gloves)	___	___	___	___	___

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	___	___	___	___	___
h. Correct labels	___	___	___	___	___
i. Understandable labels	___	___	___	___	___
j. Size of labels	___	___	___	___	___
k. Location of labels	___	___	___	___	___
l. Absence of unrelated or confusing markings	___	___	___	___	___
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

L. Using the scale to the right indicate with a check mark (✓) how adequate the Antenna Control Unit is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. AZIMUTH DISPLAY					
a. Display brightness	___	___	___	___	___
b. Absence of glare	___	___	___	___	___
c. Absence of flicker	___	___	___	___	___
d. Viewing distance	___	___	___	___	___
e. Angle of view	___	___	___	___	___
f. Correct labels	___	___	___	___	___
g. Other (specify)_____ _____.	___	___	___	___	___
2. CONTROLS					
a. Size (without gloves)	___	___	___	___	___
b. Size (with gloves)	___	___	___	___	___
c. Shape (without gloves)	___	___	___	___	___
d. Shape (with gloves)	___	___	___	___	___
e. Spacing between controls (without gloves)	___	___	___	___	___
f. Spacing between controls (with gloves)	___	___	___	___	___

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	___	___	___	___	___
h. Correct labels	___	___	___	___	___
i. Understandable labels	___	___	___	___	___
j. Size of labels	___	___	___	___	___
k. Location of labels	___	___	___	___	___
l. Absence of unrelated or confusing markings	___	___	___	___	___
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

M. Using the scale to the right indicate with a check mark (✓) how adequate the Signal Interface Distribution Unit is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. DISPLAYS					
a. Display brightness	—	—	—	—	—
b. Absence of glare	—	—	—	—	—
c. Absence of flicker	—	—	—	—	—
d. Viewing distance	—	—	—	—	—
e. Angle of view	—	—	—	—	—
f. Correct labels	—	—	—	—	—
g. Other (specify)_____ _____.	—	—	—	—	—
2. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—
m. Visibility of controls	—	—	—	—	—
n. Angle of view	—	—	—	—	—
o. Location of critical controls	—	—	—	—	—
p. Reach distance of critical controls	—	—	—	—	—
q. Location of noncritical controls	—	—	—	—	—
r. Reach distance of noncritical controls	—	—	—	—	—
s. Functional grouping (controls with related functions are grouped together)	—	—	—	—	—

	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

N. Using the scale to the right indicate with a check mark (√) how adequate the Audio Recorder is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. METERS					
a. Display brightness	___	___	___	___	___
b. Absence of glare	___	___	___	___	___
c. Absence of flicker	___	___	___	___	___
d. Viewing distance	___	___	___	___	___
e. Angle of view	___	___	___	___	___
f. Correct labels	___	___	___	___	___
g. Other (specify)_____ _____.	___	___	___	___	___
2. CONTROLS					
a. Size (without gloves)	___	___	___	___	___
b. Size (with gloves)	___	___	___	___	___
c. Shape (without gloves)	___	___	___	___	___
d. Shape (with gloves)	___	___	___	___	___
e. Spacing between controls (without gloves)	___	___	___	___	___
f. Spacing between controls (with gloves)	___	___	___	___	___

	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—
m. Visibility of controls	—	—	—	—	—
n. Angle of view	—	—	—	—	—
o. Location of critical controls	—	—	—	—	—
p. Reach distance of critical controls	—	—	—	—	—
q. Location of noncritical controls	—	—	—	—	—
r. Reach distance of noncritical controls	—	—	—	—	—
s. Functional grouping (controls with related functions are grouped together)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers.

O. Using the scale to the right indicate with a check mark (✓) how adequate the Receiver Input Unit is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. DISPLAYS					
a. Display brightness	___	___	___	___	___
b. Absence of glare	___	___	___	___	___
c. Absence of flicker	___	___	___	___	___
d. Viewing distance	___	___	___	___	___
e. Angle of view	___	___	___	___	___
f. Correct labels	___	___	___	___	___
g. Other (specify)_____ _____.	___	___	___	___	___
2. CONTROLS					
a. Size (without gloves)	___	___	___	___	___
b. Size (with gloves)	___	___	___	___	___
c. Shape (without gloves)	___	___	___	___	___
d. Shape (with gloves)	___	___	___	___	___
e. Spacing between controls (without gloves)	___	___	___	___	___
f. Spacing between controls (with gloves)	___	___	___	___	___

	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—
m. Visibility of controls	—	—	—	—	—
n. Angle of view	—	—	—	—	—
o. Location of critical controls	—	—	—	—	—
p. Reach distance of critical controls	—	—	—	—	—
q. Location of noncritical controls	—	—	—	—	—
r. Reach distance of noncritical controls	—	—	—	—	—
s. Functional grouping (controls with related functions are grouped together)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

P. Using the scale to the right indicate with a check mark (✓) how adequate the Receiver Panels (front and back) are in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. DISPLAYS					
a. Display brightness	—	—	—	—	—
b. Absence of glare	—	—	—	—	—
c. Absence of flicker	—	—	—	—	—
d. Viewing distance	—	—	—	—	—
e. Angle of view	—	—	—	—	—
f. Correct labels	—	—	—	—	—
g. Other (specify)_____ _____.	—	—	—	—	—
2. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	___	___	___	___	___
h. Correct labels	___	___	___	___	___
i. Understandable labels	___	___	___	___	___
j. Size of labels	___	___	___	___	___
k. Location of labels	___	___	___	___	___
l. Absence of unrelated or confusing markings	___	___	___	___	___
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

Q. Using the scale to the right indicate with a check mark (✓) how adequate the Computer Control Unit is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. DISPLAY					
a. Display brightness	—	—	—	—	—
b. Absence of glare	—	—	—	—	—
c. Absence of flicker	—	—	—	—	—
d. Viewing distance	—	—	—	—	—
e. Angle of view	—	—	—	—	—
f. Correct labels	—	—	—	—	—
g. Other (specify)_____ _____.	—	—	—	—	—
2. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	___	___	___	___	___
h. Correct labels	___	___	___	___	___
i. Understandable labels	___	___	___	___	___
j. Size of labels	___	___	___	___	___
k. Location of labels	___	___	___	___	___
l. Absence of unrelated or confusing markings	___	___	___	___	___
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

R. Using the scale to the right indicate with a check mark (✓) how adequate the Digital Data Synchronizer is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. DISPLAY					
a. Display brightness	—	—	—	—	—
b. Absence of glare	—	—	—	—	—
c. Absence of flicker	—	—	—	—	—
d. Viewing distance	—	—	—	—	—
e. Angle of view	—	—	—	—	—
f. Correct labels	—	—	—	—	—
g. Other (specify)_____ _____.	—	—	—	—	—
2. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—
m. Visibility of controls	—	—	—	—	—
n. Angle of view	—	—	—	—	—
o. Location of critical controls	—	—	—	—	—
p. Reach distance of critical controls	—	—	—	—	—
q. Location of noncritical controls	—	—	—	—	—
r. Reach distance of noncritical controls	—	—	—	—	—
s. Functional grouping (controls with related functions are grouped together)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

S. Using the scale to the right indicate with a check mark (✓) how adequate the Multiplexer is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. DISPLAY					
a. Display brightness	—	—	—	—	—
b. Absence of glare	—	—	—	—	—
c. Absence of flicker	—	—	—	—	—
d. Viewing distance	—	—	—	—	—
e. Angle of view	—	—	—	—	—
f. Correct labels	—	—	—	—	—
g. Other (specify)_____ _____.	—	—	—	—	—
2. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—
m. Visibility of controls	—	—	—	—	—
n. Angle of view	—	—	—	—	—
o. Location of critical controls	—	—	—	—	—
p. Reach distance of critical controls	—	—	—	—	—
q. Location of noncritical controls	—	—	—	—	—
r. Reach distance of noncritical controls	—	—	—	—	—
s. Functional grouping (controls with related functions are grouped together)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

T. Using the scale to the right indicate with a check mark (✓) how adequate the Demultiplexer is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. DISPLAY					
a. Display brightness	___	___	___	___	___
b. Absence of glare	___	___	___	___	___
c. Absence of flicker	___	___	___	___	___
d. Viewing distance	___	___	___	___	___
e. Angle of view	___	___	___	___	___
f. Correct labels	___	___	___	___	___
g. Other (specify)_____ _____.	___	___	___	___	___
2. CONTROLS					
a. Size (without gloves)	___	___	___	___	___
b. Size (with gloves)	___	___	___	___	___
c. Shape (without gloves)	___	___	___	___	___
d. Shape (with gloves)	___	___	___	___	___
e. Spacing between controls (without gloves)	___	___	___	___	___
f. Spacing between controls (with gloves)	___	___	___	___	___

	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	___	___	___	___	___
h. Correct labels	___	___	___	___	___
i. Understandable labels	___	___	___	___	___
j. Size of labels	___	___	___	___	___
k. Location of labels	___	___	___	___	___
l. Absence of unrelated or confusing markings	___	___	___	___	___
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___

	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

U. Using the scale to the right indicate with a check mark (✓) how adequate the Alternate Mode Switching Unit is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. CONTROLS					
a. Size (without gloves)	___	___	___	___	___
b. Size (with gloves)	___	___	___	___	___
c. Shape (without gloves)	___	___	___	___	___
d. Shape (with gloves)	___	___	___	___	___
e. Spacing ween controls ithout gloves)	___	___	___	___	___
f. Spacing between controls (with gloves)	___	___	___	___	___
g. Resistance (too easy to turn or push, or too hard to turn or push)	___	___	___	___	___
h. Correct labels	___	___	___	___	___
i. Understandable labels	___	___	___	___	___
j. Size of labels	___	___	___	___	___
k. Location of labels	___	___	___	___	___
l. Absence of unrelated or confusing markings	___	___	___	___	___

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

2. Please explain any Borderline, Inadequate, or Very Inadequate answers:

V. Using the scale to the right indicate with a check mark (√) how adequate the Amplifier Control Unit is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. METER & DISPLAY					
a. Display brightness	___	___	___	___	___
b. Absence of glare	___	___	___	___	___
c. Absence of flicker	___	___	___	___	___
d. Viewing distance	___	___	___	___	___
e. Angle of view	___	___	___	___	___
f. Correct labels	___	___	___	___	___
g. Other (specify)_____ _____.	___	___	___	___	___
2. CONTROLS					
a. Size (without gloves)	___	___	___	___	___
b. Size (with gloves)	___	___	___	___	___
c. Shape (without gloves)	___	___	___	___	___
d. Shape (with gloves)	___	___	___	___	___
e. Spacing between controls (without gloves)	___	___	___	___	___
f. Spacing between controls (with gloves)	___	___	___	___	___

	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—
m. Visibility of controls	—	—	—	—	—
n. Angle of view	—	—	—	—	—
o. Location of critical controls	—	—	—	—	—
p. Reach distance of critical controls	—	—	—	—	—
q. Location of noncritical controls	—	—	—	—	—
r. Reach distance of noncritical controls	—	—	—	—	—
s. Functional grouping (controls with related functions are grouped together)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

W. Using the scale to the right indicate with a check mark (✓) how adequate the Exciter Panels are in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. METERS					
a. Display brightness	___	___	___	___	___
b. Absence of glare	___	___	___	___	___
c. Absence of flicker	___	___	___	___	___
d. Viewing distance	___	___	___	___	___
e. Angle of view	___	___	___	___	___
f. Correct labels	___	___	___	___	___
g. Other (specify)_____ _____.	___	___	___	___	___
2. CONTROLS					
a. Size (without gloves)	___	___	___	___	___
b. Size (with gloves)	___	___	___	___	___
c. Shape (without gloves)	___	___	___	___	___
d. Shape (with gloves)	___	___	___	___	___
e. Spacing between controls (without gloves)	___	___	___	___	___
f. Spacing between controls (with gloves)	___	___	___	___	___

	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—
m. Visibility of controls	—	—	—	—	—
n. Angle of view	—	—	—	—	—
o. Location of critical controls	—	—	—	—	—
p. Reach distance of critical controls	—	—	—	—	—
q. Location of noncritical controls	—	—	—	—	—
r. Reach distance of noncritical controls	—	—	—	—	—
s. Functional grouping (controls with related functions are grouped together)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

X. Using the scale to the right indicate with a check mark (✓) how adequate the Main Circuit Breaker Panel is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. METERS					
a. Display brightness	___	___	___	___	___
b. Absence of glare	___	___	___	___	___
c. Absence of flicker	___	___	___	___	___
d. Viewing distance	___	___	___	___	___
e. Angle of view	___	___	___	___	___
f. Correct labels	___	___	___	___	___
g. Other (specify)_____ _____.	___	___	___	___	___
2. CONTROLS					
a. Size (without gloves)	___	___	___	___	___
b. Size (with gloves)	___	___	___	___	___
c. Shape (without gloves)	___	___	___	___	___
d. Shape (with gloves)	___	___	___	___	___
e. Spacing between controls (without gloves)	___	___	___	___	___
f. Spacing between controls (with gloves)	___	___	___	___	___

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—
m. Visibility of controls	—	—	—	—	—
n. Angle of view	—	—	—	—	—
o. Location of critical controls	—	—	—	—	—
p. Reach distance of critical controls	—	—	—	—	—
q. Location of noncritical controls	—	—	—	—	—
r. Reach distance of noncritical controls	—	—	—	—	—
s. Functional grouping (controls with related functions are grouped together)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

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Y. Using the scale to the right indicate with a check mark (✓) how adequate the Manual Values for Mast Panel is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. METER					
a. Display brightness	—	—	—	—	—
b. Absence of glare	—	—	—	—	—
c. Absence of flicker	—	—	—	—	—
d. Viewing distance	—	—	—	—	—
e. Angle of view	—	—	—	—	—
f. Correct labels	—	—	—	—	—
g. Other (specify)_____ _____.	—	—	—	—	—
2. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—
m. Visibility of controls	—	—	—	—	—
n. Angle of view	—	—	—	—	—
o. Location of critical controls	—	—	—	—	—
p. Reach distance of critical controls	—	—	—	—	—
q. Location of noncritical controls	—	—	—	—	—
r. Reach distance of noncritical controls	—	—	—	—	—
s. Functional grouping (controls with related functions are grouped together)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

2. Using the scale to the right indicate with a check mark (✓) how adequate the Deploy Switch for Data Link Antenna is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—

	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
m. Visibility of controls	—	—	—	—	—
n. Angle of view	—	—	—	—	—
o. Location of critical controls	—	—	—	—	—
p. Reach distance of critical controls	—	—	—	—	—
q. Location of noncritical controls	—	—	—	—	—
r. Reach distance of noncritical controls	—	—	—	—	—
s. Functional grouping (controls with related functions are grouped together)	—	—	—	—	—
t. Control type (type of control is appropriate for type of function)	—	—	—	—	—
u. Other (specify)_____ _____.	—	—	—	—	—

2. **Please explain any Borderline, Inadequate, or Very Inadequate answers:**

AA. Using the scale to the right indicate with a check mark (✓) how adequate the Generator Control Panel is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. METERS					
a. Display brightness	—	—	—	—	—
b. Absence of glare	—	—	—	—	—
c. Absence of flicker	—	—	—	—	—
d. Viewing distance	—	—	—	—	—
e. Angle of view	—	—	—	—	—
f. Correct labels	—	—	—	—	—
g. Other (specify)_____ _____.	—	—	—	—	—
2. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
g. Resistance (too easy to turn or push, or too hard to turn or push)	___	___	___	___	___
h. Correct labels	___	___	___	___	___
i. Understandable labels	___	___	___	___	___
j. Size of labels	___	___	___	___	___
k. Location of labels	___	___	___	___	___
l. Absence of unrelated or confusing markings	___	___	___	___	___
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

3. Please explain any Borderline, Inadequate, or Very Inadequate answers:

BB. Using the scale to the right indicate with a check mark (√) how adequate the Emergency Air Supply Switch is in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. CONTROLS					
a. Size (without gloves)	___	___	___	___	___
b. Size (with gloves)	___	___	___	___	___
c. Shape (without gloves)	___	___	___	___	___
d. Shape (with gloves)	___	___	___	___	___
e. Spacing between controls (without gloves)	___	___	___	___	___
f. Spacing between controls (with gloves)	___	___	___	___	___
g. Resistance (too easy to turn or push, or too hard to turn or push)	___	___	___	___	___
h. Correct labels	___	___	___	___	___
i. Understandable labels	___	___	___	___	___
j. Size of labels	___	___	___	___	___
k. Location of labels	___	___	___	___	___
l. Absence of unrelated or confusing markings	___	___	___	___	___

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

2. Please explain any Borderline, Inadequate, or Very Inadequate answers:

CC. Using the scale to the right indicate with a check mark (✓) how adequate the Ground Rod Drive Assembly Controls are in each of the following areas:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. CONTROLS					
a. Size (without gloves)	—	—	—	—	—
b. Size (with gloves)	—	—	—	—	—
c. Shape (without gloves)	—	—	—	—	—
d. Shape (with gloves)	—	—	—	—	—
e. Spacing between controls (without gloves)	—	—	—	—	—
f. Spacing between controls (with gloves)	—	—	—	—	—
g. Resistance (too easy to turn or push, or too hard to turn or push)	—	—	—	—	—
h. Correct labels	—	—	—	—	—
i. Understandable labels	—	—	—	—	—
j. Size of labels	—	—	—	—	—
k. Location of labels	—	—	—	—	—
l. Absence of unrelated or confusing markings	—	—	—	—	—

	Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate
	(5)	(4)	(3)	(2)	(1)
m. Visibility of controls	___	___	___	___	___
n. Angle of view	___	___	___	___	___
o. Location of critical controls	___	___	___	___	___
p. Reach distance of critical controls	___	___	___	___	___
q. Location of noncritical controls	___	___	___	___	___
r. Reach distance of noncritical controls	___	___	___	___	___
s. Functional grouping (controls with related functions are grouped together)	___	___	___	___	___
t. Control type (type of control is appropriate for type of function)	___	___	___	___	___
u. Other (specify)_____ _____.	___	___	___	___	___

2. Please explain any Borderline, Inadequate, or Very Inadequate answers:

II. Workspace

A. Using the scale to the right indicate with a check mark (✓) how adequate the workspace in the TACJAM is for each of the following factors:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. Leg room	___	___	___	___	___
2. Elbow room	___	___	___	___	___
3. Seating					
a. Horizontal adjustment	___	___	___	___	___
b. Vertical adjustment	___	___	___	___	___
c. Backrest	___	___	___	___	___
d. Cushioning	___	___	___	___	___
4. Storage room (for papers, personal items, combat gear, etc.)	___	___	___	___	___
5. Other (specify)_____ _____.	___	___	___	___	___

6. Please explain any Borderline, Inadequate, or Very Inadequate responses:

B. I would like you to take a few minutes now to consider the overall configuration of the TACJAM System. Based on your experience with the system, could the system be made more efficient and easier to use by arranging the components in a different way? If so, how would you arrange them? (Please support your answer).

III. Environment

Using the scale to the right indicate with a check mark (✓) how adequate the environmental conditions in your work workspace are:	Very Adequate (5)	Adequate (4)	Borderline (3)	Inadequate (2)	Very Inadequate (1)
1. Temperature	___	___	___	___	___
2. Ventilation	___	___	___	___	___
3. Noise	___	___	___	___	___
4. Vibration	___	___	___	___	___
5. Illumination	___	___	___	___	___
6. Other (specify)_____ _____.	___	___	___	___	___

IV. Safety

Indicate with a check mark (✓) if any of the hazards listed to the right exist for the following controls and indicators (please explain your answers).

	(1) Electrical Hazard	(2) Heat Hazard	(3) Structural Hazard (sharp edges, entangling)	(4) Mechanical Hazard (moving parts)	(5) Extreme brightness	(6) Extreme loudness
1. TACJAM Control Panel	—	—	—	—	—	—
2. Function Button Panel	—	—	—	—	—	—
3. Receiver Control Panel	—	—	—	—	—	—
4. Keyboard	—	—	—	—	—	—
5. Plasma Display Indicator Panel	—	—	—	—	—	—
6. Panoramic Indicator	—	—	—	—	—	—
7. Auxiliary Equipment Control Panel	—	—	—	—	—	—
8. Antenna Display Junction Box	—	—	—	—	—	—
9. Filtered 400 Hz Power Distribution Box	—	—	—	—	—	—
10. Transmitter Panel	—	—	—	—	—	—
11. Power Interlock Panel	—	—	—	—	—	—
12. Antenna Control Unit	—	—	—	—	—	—
13. Signal Interface Distribution Unit	—	—	—	—	—	—
14. Audio Recorder	—	—	—	—	—	—
15. Receiver Input Unit	—	—	—	—	—	—

		Electrical Hazard (1)	Heat Hazard (2)	Structural Hazard (sharp edges, entangling) (3)	Mechanical Hazard (moving parts) (4)	Extreme brightness (5)	Extreme loudness (6)
16.	Receiver Panels	—	—	—	—	—	—
17.	Computer Control Unit	—	—	—	—	—	—
18.	Digital Data Synchronizer	—	—	—	—	—	—
19.	Alternate Mode Switching Unit	—	—	—	—	—	—
20.	Amplifier Control Unit	—	—	—	—	—	—
21.	Exciter Panels	—	—	—	—	—	—
22.	Main Circuit Breaker Panel	—	—	—	—	—	—
23.	Manual Valves for Mast Panel	—	—	—	—	—	—
24.	Deploy Switch for Data Link Antenna	—	—	—	—	—	—
25.	Generator Control Panel	—	—	—	—	—	—
26.	Emergency Air Supply Switch	—	—	—	—	—	—
27.	Ground Rod Drive Assembly	—	—	—	—	—	—
28.	Equipment Shelter	—	—	—	—	—	—
29.	M548 Cargo Carrier	—	—	—	—	—	—
30.	Other (specify)_____ _____.	—	—	—	—	—	—

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31. Please list any other safety hazards.

V. Operating Procedures

Listed below are the procedures performed by TACJAM operators. Please rate, using a check mark (✓), how easy or difficult it is to perform each of these procedures, and how easy or difficult it is to understand the Operator's Manual for each of these procedures. Also, describe any difficulties and possible solutions to the difficulties.

	Very Easy (5)	Easy (4)	Borderline (3)	Difficult (2)	Very Difficult (1)
A. Initial Adjustments					
Procedures	___	___	___	___	___
Manual	___	___	___	___	___
B. Preliminary Operating Procedures					
Procedures	___	___	___	___	___
Manual	___	___	___	___	___
C. TACJAM Startup and Checkout					
1. Power-up					
Procedures	___	___	___	___	___
Manual	___	___	___	___	___
2. Computer Start-up					
Procedures	___	___	___	___	___
Manual	___	___	___	___	___
3. Reloading Program File					
Procedures	___	___	___	___	___
Manual	___	___	___	___	___
4. Processor Test					
Procedures	___	___	___	___	___
Manual	___	___	___	___	___
5. System Test					
Procedures	___	___	___	___	___
Manual	___	___	___	___	___
6. Fault Page					
Procedures	___	___	___	___	___
Manual	___	___	___	___	___

	Very Easy (5)	Easy (4)	Borderline (3)	Difficult (2)	Very Difficult (1)
7. Transmitter Test					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
D. Loading the Bootstrap					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
E. Checking Existing Tasking					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
F. Spot Page					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
G. Tasking Data Fields					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
H. Alternate Tasking					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
I. Selection of Tasking Parameters					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
J. Transmitter Modulation Types					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
K. Lockout Page					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—

	Very Easy (5)	Easy (4)	Borderline (3)	Difficult (2)	Very Difficult (1)
L. Automatic Operation					
1. Arm or inhibit transmitters					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
2. Inhibit individual spots					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
3. Reposition antennas					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
M. Direct Operator Control					
1. Receiver Selection					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
2. Receiver Tuning					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
3. Manual Jamming					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
4. Hold Function					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
5. Command Lines					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
N. Remote Operation					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—

	(5) Very Easy	(4) Easy	(3) Borderline	(2) Difficult	(1) Very Difficult
O. Operation Under Unusual Conditions					
1. Extreme heat					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
2. Extreme cold					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
3. High humidity					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
4. High wind					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
P. TACJAM Shutdown					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
Q. TACJAM Preventive Maintenance					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
R. Heat Exchanger Maintenance					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
S. Vehicle Preventive Maintenance					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
T. Troubleshooting					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—
U. Other (specify)_____					
Procedures	—	—	—	—	—
Manual	—	—	—	—	—

V. Please explain any difficulties you had with operating procedures or the manual.

VI. Training

A. How many hours have you spent operating the TACJAM system? ____hrs.

B. Please describe the formal training you received on thp TACJAM system.

Dates	Location	No. of Hrs. of training	Description of training

C. After completing the formal training program for the TACJAM system, how confident were you that you could adequately carry out a TACJAM mission?

_____ Very Confident
_____ Confident
_____ Borderline
_____ Unconfident
_____ Very Unconfident

D. Now that you have finished the TACJAM test, how confident are you that you can adequately carry out a TACJAM mission?

_____ Very Confident
_____ Confident
_____ Borderline
_____ Unconfident
_____ Very Unconfident

E. Please describe any criticisms you have of the formal training program for TACJAM operators.

F. Please describe any parts of the TACJAM system or procedures used in operating the TACJAM system which you feel should receive special emphasis in developing a formal training program for TACJAM operators.

APPENDIX B

TACJAM Maintenance Questionnaire

Name _____ Date _____

MOS _____

Please answer each of the following questions as best you can. Base your responses on the experiences which you have had on this test.

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I. Test Equipment

A. BITE

1. Rate the general usefulness of the BITE feature of the TACJAM system. (Check one)

_____ Extremely useful
_____ Quite useful
_____ Somewhat useful
_____ Slightly useful
_____ Not at all useful

2. Please describe any major problems you had with the BITE feature.

_____

_____

_____

_____

_____

B. Test Maintenance and Diagnostic Equipment (TMDE)

1. Rate the usefulness of the TMDE for TACJAM. (Check one)

_____ Extremely useful
_____ Quite useful
_____ Somewhat useful
_____ Slightly useful
_____ Not at all useful

2. Please describe any major problems you had with the TMDE.

_____

_____

_____

_____

_____

3. How satisfactory is the TMDE for use in a tactical environment? (Check one)

_____ Very satisfactory
_____ Satisfactory
_____ Borderline
_____ Unsatisfactory
_____ Very unsatisfactory

4. Please explain "Borderline", "Unsatisfactory", or "Very unsatisfactory" answers.

_____

_____

_____

_____

_____

C. Automated Test Equipment (ATE)

1. Rate the usefulness of the ATE for TACJAM. (Check one)

_____ Extremely useful
_____ Quite useful
_____ Somewhat useful
_____ Slightly useful
_____ Not at all useful

2. Please describe any major problems you had with the ATE.

_____

_____

_____

_____

_____

II. Repair

A. Test Points

1. How adequate is the accessibility of the maintenance test points of the TACJAM system? (Check one)

_____ Very adequate
_____ Adequate
_____ Borderline
_____ Inadequate
_____ Very inadequate

2. Please explain, "Borderline", "Inadequate", or "Very inadequate" answers.

_____

_____

_____

_____

_____

B. Subcomponents

1. How adequate is the TACJAM system with respect to the ease of replacing subcomponents. (Check one)

_____ Very adequate
_____ Adequate
_____ Borderline
_____ Inadequate
_____ Very inadequate

2. Please explain "Borderline", "Inadequate", or "Very inadequate" answers.

_____

_____

_____

_____

_____

C. Major Components

1. How adequate is the TACJAM system with respect to the ease of replacing major components? (Check one)

_____ Very adequate
_____ Adequate
_____ Borderline
_____ Inadequate
_____ Very inadequate

2. Please explain, "Borderline", "Inadequate", and "Very inadequate" answers.

_____

_____

_____

_____

_____

D. Calibration

1. What problems, if any did you have in calibrating the TACJAM system?

III. Technical Manuals

A. Clarity

1. Rate the maintenance technical manual with respect to clarity of presentation of information. (Check one)

_____ Very satisfactory
_____ Satisfactory
_____ Borderline
_____ Unsatisfactory
_____ Very unsatisfactory

2. Explain "Borderline", "Unsatisfactory", or "Very unsatisfactory" answers.

_____

_____

_____

_____

_____

B. Accuracy

1. Rate the maintenance technical manual with respect to accuracy of information.

_____ Very satisfactory
_____ Satisfactory
_____ Borderline
_____ Unsatisfactory
_____ Very unsatisfactory

2. Explain "Borderline", "Unsatisfactory", and "Very unsatisfactory" answers.

_____

_____

_____

_____

_____

C. Simplicity

1. Rate the maintenance technical manual with respect to simplicity of organization of information (i.e., is it easy to find information in the manual?).

_____ Very satisfactory
_____ Satisfactory
_____ Borderline
_____ Unsatisfactory
_____ Very unsatisfactory

2. Explain "Borderline", "Unsatisfactory", or "Very unsatisfactory" answers.

_____

_____

_____

_____

_____

D. Completeness

1. Rate the maintenance technical manual with respect to completeness of information.

_____ Very satisfactory
_____ Satisfactory
_____ Borderline
_____ Unsatisfactory
_____ Very unsatisfactory

2. Explain "Borderline", "Unsatisfactory", or "Very unsatisfactory" answers.

_____

_____

_____

_____

_____

IV. Logistics

A. Procedures

1. How adequate are the maintenance supply procedures for TACJAM?

_____ Very adequate
_____ Adequate
_____ Borderline
_____ Inadequate
_____ Very inadequate

2. Explain "Borderline", "Inadequate", or "Very inadequate" answers.

_____

_____

_____

_____

_____

B. Allocation

1. How adequate is the maintenance allocation concept for the TACJAM system?

_____ Very adequate
_____ Adequate
_____ Borderline
_____ Inadequate
_____ Very inadequate

2. Explain "Borderline", "Inadequate", or "Very inadequate" answers.

_____

_____

_____

_____

_____

APPENDIX C

TACJAM FOLLOW-ON QUESTIONNAIRE INTERVIEW FOR MAINTENANCE PERSONNEL

NAME_____ DATE_____

MOS_____

The following questionnaire includes questions on TACJAM maintenance that were not covered in the previous questionnaire. Please answer the questions as best as you can, taking as much time as you feel is necessary. The interviewer will answer any questions you may have and will write down any additional comments you would like to make.

1. TRAINING

A. What type of maintenance are you trained to perform on TACJAM?

_____ Organizational Maintenance

_____ Intermediate Maintenance

_____ Depot Maintenance

B. Please describe the training program you underwent in acquiring your knowledge of the TACJAM system. Include formal course titles, subject matter of courses, location of courses, length of courses, and date of courses. If you had no formal courses, describe how you became knowledgeable of TACJAM by listing OJT locations, time periods of OJT, etc.

II. ORGANIZATIONAL MAINTENANCE

A. Tools.

1. Were you issued any special tools, other than the standard tool kit, for performing organizational maintenance on TACJAM?

_____YES _____NO

If yes, list them.

2. Did you need additional tools for:

1. Preventive maintenance?	_____Yes	_____No
2. Troubleshooting?	_____Yes	_____No
3. Replacing boxes?	_____Yes	_____No
4. Other maintenance?	_____Yes	_____No

If yes, please explain.

B. Special Skills.

Were any special skills required, other than those that a school trained maintenance man with a 33S MOS would have, to perform organizational maintenance on TACJAM?

_____YES _____NO

If yes, please explain.

C. Repair Parts.

Did you have any problems in obtaining repair parts at the level of organizational maintenance?

_____YES _____NO

If yes, please explain.

D. Maintenance Procedures.

1. Are there any maintenance procedures currently assigned to the level of organizational maintenance which could actually be performed by TACJAM operators?

_____YES _____NO

If yes, please explain.

2. Are there any maintenance procedures currently assigned to the level of organizational maintenance which should actually be assigned to the level of intermediate or depot maintenance?

_____YES _____NO

If yes, please explain.

3. Are there any maintenance procedures at the level of organizational maintenance that are hazardous?

_____YES _____NO

If yes, please explain them and, if possible, give suggestions on how to reduce the hazard.